STUDIES ON CLIMATE AND CROPS*

1. VARIATIONS IN THE DISTRIBUTION OF ATMOSPHERIC PRESSURE IN NORTH AMERICA

BY

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In a memoir recently published I have given the results of a comparative study of the variations of annual mean temperatures.† As a continuation of this study I shall examine, in the present paper, the data of annual mean atmospheric pressures, and to make clear the object of these investigations I shall begin with a short summary of the principal conclusions of my work on temperature. These conclusions are :

1. At a given place any excess or deficiency in a yearly mean temperature affects, in the same way, the whole layer of the atmosphere accessible to direct observations. Moreover, it seems that the variations are more accentuated at high-level stations.

2. The climatological anomalies are regional. For long series of observations the curves of lustra means show that minima of certain regions occur at the same time as maxima of other regions. Most probably the length of the cycles differ in different countries, as also do the successive waves in the curves of each station.

3. In Europe there seems to exist a rhythmical oscillation of the isotherms. Utilizing the results of those stations of France, Germany, and Russia, where homogeneous series of observations exist for the period of years 1851 to 1900, I have made maps showing the distribution of the departures of the means of each of the five decades of years from the general means. These maps show that the departures observed in the east and west are generally opposite. In other words, the temperatures are too low in Russia when they are too high in France, and *vice versa*.

From the above statements, it results that it was necessary to solve the problem of compensations before it was possible to know whether changes really exist in the quantity of heat accumulated in the Earth's atmosphere. For this purpose I collected the mean temperatures, for the years 1891 to 1900, for all the countries where meteorological observations have been pursued during those years. For each station I calculated the mean of the ten years, the annual departures from that mean, and the

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* The author has come to the United States to pursue here his investigations on changes of climate. His first contribution to this subject was his discovery, 10 years ago, of the former great extension of glaciation in the antarctic regions. He is making a systematic study of climatic and crop data with a view of presenting the various factors that may connect astrophysical phenomena with those of commercial geography. His second paper will treat of variations in the yield of wheat in connection with climatic changes.—THE EDITOR.

† L'enchaînement des variations climatiques, Bruxelles, 1909.

difference between the means of the two lustra. In setting forth these figures on maps I was led to the following conclusions :

4. The temperature of the Earth's atmosphere was higher during the lustrum 1896–1900 than during that of 1891–1895. The difference can, of course, only be estimated, and it seems to be between 0.2° and 0.5° C.

5. The year 1893 was the coldest and the year 1900 the warmest of the decade taken into consideration. It seems that the mean temperature for the globe was at least 0.5 C. higher in 1900 than in 1893.

6. The areas of positive and negative departures, on the annual maps, show that most probably dynamical phenomena in our atmosphere cause extremely slow displacement of waves characterized by a deficiency or excess of heat. I have given the name "thermopleions" to the waves of positive departures, and have called "antipleions" the areas where the temperature is below the normal—that is, below the mean of the ten years. The pleions and antipleions, while changing their forms and positions, can be followed in most cases from one year to another.

Now, as 1893 was precisely a year of maximum sunspots and 1900 was near a year of minimum, it seems that the phenomenon of sunspots is in correlation with fluctuations of the quantity of energy radiated by the sun, and also that the first cause of climatological variations is extra-terrestrial. To arrive at a more definite conclusion, I have examined the curve of the monthly mean temperatures noted at Batavia since 1866. This curve shows that, besides the period of sunspots, other periods, of longer or shorter duration, play a more important rôle in the observed changes of temperature.

On the other hand, as we have seen, besides the extra-terrestrial cause on account of which the terrestrial atmosphere, considered as a whole, does not remain constant, other factors, of a purely geographical order, modify the distribution of excess or deficiency of received radiated heat to such an extent that in the study of observed variations these factors must first be considered.

Leaving, therefore, for the moment, the correlations between the sun and atmospheric phenomena and the manner of formation of the thermopleions, I shall try to make plain the mechanism of the propagation of these changes of temperature.

The established facts show that in all probabilty this propagation is essentially due to changes in the atmospheric circulation. Some of these changes may be rhythmical,* others may be periodical† or progressive. We should know, therefore, the modifications of the velocity and direction of the wind. The anomalies occurring in the distribution of atmospheric pressure may, however, serve as a first approximation. Such anomalies exist even if we take into consideration the departures of lustrum means, as I demonstrated in a paper published over a year ago.‡ In the present paper I shall examine more in detail the annual departures of pressure noted in the United States.

Two hypotheses formulated on the subject of the variations of atmospheric pressure have attracted much attention. According to the first hypothesis, the baro-

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* The diagram of the yearly resultants of the direction of the wind at St. Petersburg which I published in my study on the changes of the climate of Warsaw (*Prace matematyczno fizyczne, 1908*) may be cited as an example.

† Such seems to be the case with the wind velocity on mountain-peaks. (Arctowski in *Bull.* Soc. belge d'Astronomie, 1907.)

‡ *Comptes Rendus* de l'Acad. d. Sciences de Paris.

metric gradients between areas of low and high pressure, as well as the ranges of annual variation, increase and decrease progressively during periods of about 35 years. Under the second hypothesis, the climatic anomalies of western Europe are explained by temporary accentuations or diminutions of the Atlantic "centers of action."

It is sufficient to look at the map of annual isobars in Bartholomew's Atlas, which has been reproduced in many publications, to see that the high-pressure belt of the northern hemisphere crosses the United States, and that toward the north, in Canada, along the axis of the continent, an area of high pressure completely separates the Atlantic and Pacific "centers of action" of low barometric pressure. It is evident, therefore, that if really, under the influence of solar phenomena, for example, the atmospheric pressure increases in the region of Iceland, and at the same time diminishes at the Azores, or *vice versa*, and especially if the same thing happens in the same way at the "centers of action" of the Northern Pacific Ocean, the data of the American stations, entirely comprised between these four "centers of action," will give most important information.

I pass now to the main object of this paper.

Utilizing the data collected by Sir Norman Lockyer*, I have inserted on maps the annual departures, from the general means of the years 1876 to 1900, for the following stations:

Jacobshavn, Berufjord, Stykkisholm, Tromsö, Aalesund, Brussels, Ponta-Delgada, Lisbon, Madrid, Aberdeen, Valencia, Duluth, Denver, Galveston, Montreal, Toronto, Washington, Nashville and Mobile.

An important fact to be noted in regard to these maps is the range of possible variations. At Tromsö, for example, the highest mean was in 1897, and the lowest in 1887. The difference between the two values in thousandths of an inch is 0.220. The following figures give, in the order of the stations mentioned above, the corresponding greatest differences :

0.166, 0.220, 0.212, 0.220, 0.169, 0.098, 0.144, 0.136, 0.121, 0.158, 0.203, 0.093, 0.054, 0.096, 0.113, 0.087, 0.089, 0.082, 0.069.

It is only in Lapland, Iceland and Ireland, therefore, that the differences are higher than 0.200, while in the United States the possible range is less than 0.100. It is found, by placing these figures on maps, that the curve embracing the differences higher than 0.150 extends from Denmark toward Scotland, passes downward by the Bay of Biscay into the neighborhood of the Azores, then up again toward Labrador. The curve of the differences 0.100 takes in Spain and the Azores, then mounts toward Canada. In North America the atmospheric pressure varies between much narrower limits than on the Atlantic, and the axis following which the anomalies may be greatest forms an arc, which starts at the high-pressure belt of the Azores and tends toward the North Cape, passing south of Iceland. These facts permit us to presume that the anomalies in the distribution of atmospheric pressure, in the United States, may be directly influenced by those of the Atlantic, as well as Europe may be influenced by them. The annual maps I have traced from the figures of Lockyer's tables in no way contradict this supposition. To get a clear idea of the exact state of things, I supplemented Lockyer's figures by the annual departures published by Frank H. Bigelow, in his report on atmospheric pressure in the United States, and those of the summaries of the *Monthly Weather Review*.

A first approximation is furnished by a detailed study of the data of Table 55 in Bigelow's memoir. Bigelow has subdivided the data of 202 stations in the United

* Monthly Mean Values of Barometric Pressure. London, 1908.

States into groups, and has formed for each group the mean departures for the years from 1873 to 1899. In this way the following table has been formed:

	N. ATLANTIC.	S. ATLANTIC.	LAKE REGION.	W. GULF.	N. PLATEAU.	S. PLATEAU.	PACIFIC.
1876......	—0.020	—0.002	—0.012	+0.007	—0.020	+0.003	0.
77......	+ 5	—10	+11	+ 2	— 8	— 9	—12
78......	—67	—56	—51	—49	—28	—25	—31
79......	+10	+17	+10	+ 7	—24	— 9	— 4
1880......	+21	+25	— 6	+13	— 7	— 8	+19
81......	— 8	—14	+ 2	—15	— 4	—13	— 1
82......	+20	+13	+ 7	+ 1	— 4	— 1	+ 7
83......	+31	+18	+15	+15	+18	+11	+16
84......	— 1	— 8	+ 2	— 6	— 7	— 5	—27
85......	—33	—31	—20	—12	— 5	+ 8	—15
86......	— 6	—13	0.	— 9	0.	+ 5	— 2
87......	— 1	— 2	+ 1	— 5	— 6	— 1	+ 1
88......	— 1	+ 4	+24	+ 8	+11	+ 4	—16
89......	—11	—12	+ 8	+ 6	+16	+22	—15
1890......	— 1	+12	+12	+11	+14	+20	+16
91......	+15	+ 6	+ 7	+ 1	— 7	— 5	+ 3
92......	— 8	+ 6	+20	+ 4	+ 8	+ 2	+ 6
93......	—16	—19	—32	—21	—18	—12	+ 9
94......	+17	+ 9	—12	+12	— 5	+14	+ 8
95......	— 8	— 7	—10	+ 6	+10	+12	+ 8
96......	+10	+15	+ 6	+ 9	+ 5	+ 8	— 4
97......	+ 8	+ 2	+11	0.	+12	+ 6	+ 7
98......	— 3	— 1	—11	— 3	+12	+ 1	— 1
99......	+11	+ 4	+ 2	0.	— 4	— 3	+ 1

The maps I have drawn with the aid of these figures are most instructive. I take at random those of the years 1888, 1889 and 1890.

The map of 1888 shows that the greatest excess above the normal pressure has been noted in Wisconsin. From this center of hyperpressure the figures diminish towards the Atlantic and Pacific, and, on both sides, in the N. E. and in California, the departures are negative. Drawing the curves of equidepartures for the three years considered, maps are obtained which show that the area of hyperpressure maintained itself during those years, and that its center moved progressively from the Lake Superior region towards the Gulf of California. The highest positive departures for those years are but 0.024, 0.022 and 0.020. This is a matter of small excess in the atmospheric pressure. However, if these figures be compared with the possible range of values, deduced from the differences between the highest and lowest observed means (observe that the departures have been lessened by the fact that they represent the means of a certain number of different stations), it is conclusive that here is a phenomenon which might play an important part in the climatological variations occurring in North America.

The fact of a displacement from N. E. to S. W., which has been established by the preceding example, is not exceptional. On the contrary, an examination of the maps drawn with the aid of Bigelow's table shows the important fact that the areas of excess or deficit pressure generally move from the E. towards the W., from the Atlantic towards the Pacific. In 1877, for example, there was a center of hyperpressure over the Lake region. In 1878 the pressure was abnormally low over the entire United States; still, the wave of hyperpressure seems to have maintained itself, moving westward meanwhile, because the least negative departures are to be found in the plateau region. The figures are—0.028 and—0.025 against—0.067,

which is the mean of the departures of the northeastern stations. Further, this extraordinary minimum, notably lessened, is observed in 1879 in the N. W., and seems to have been pushed there by a positive wave coming from the Atlantic. The

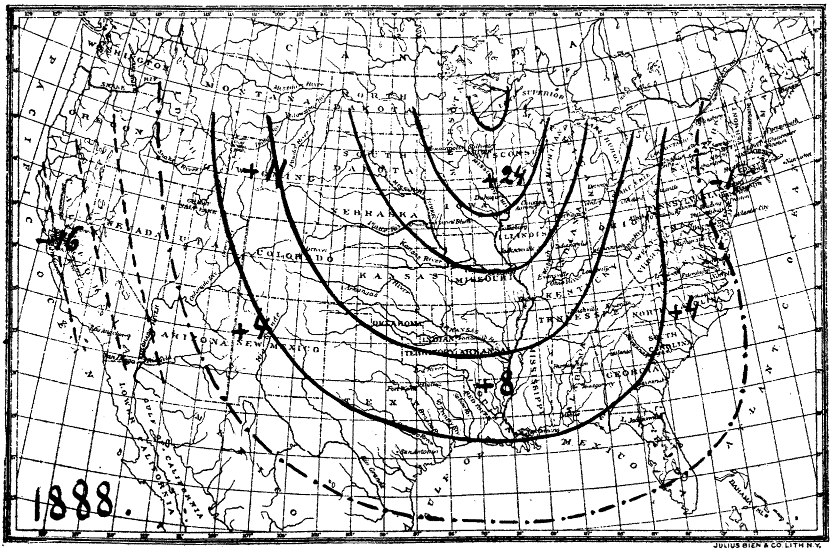

FIG. 1.

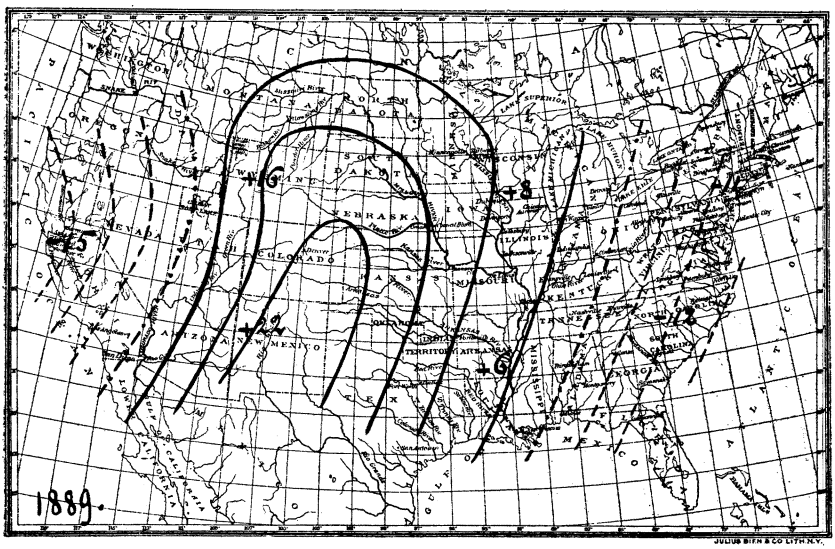

FIG. 2.

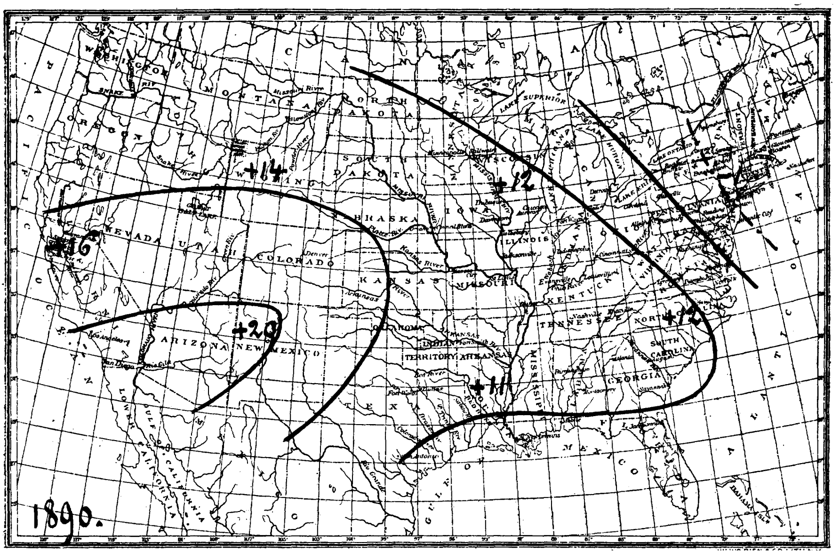

FIG. 3.

maps of which I speak can easily be drawn by using the figures of the above table. I will not dwell longer on this, inasmuch as these maps should be considered suggestive rather than demonstrative.

In order to understand the dynamical phenomena better, I have drawn more detailed maps by using the departures of the different stations. For the maps of the years 1876 to 1899 I have used the figures of Bigelow's tables, and for those of 1897 to 1908 I have used those of the annual summaries of the *Monthly Weather Review*. These maps show that in reality the changes in the distribution of pressure are extremely complicated, and that to thoroughly understand the displacements of maxima and minima which appear from year to year it is necessary to utilize the figures of all available stations. Insufficient comparisons can only lead to vague conclusions, and the real extent of practical conclusions that one has a right to look for, from a deeper study of this subject, is so great that a serious effort to completely solve the problem is justified. The principal difficulty in accomplishing this is the fact that the available figures are far from being perfect.

The maps made from using the departures calculated and published by the Weather Bureau contain many errors which are inevitable, because the departures are taken from means of more or less long series of observations. It is impossible to eliminate this lack of homogeneity if one wishes to use all available data. Then, too, in most cases the stations have been moved from one place to another, some of them several times. Therefore, the corrections which have been applied to render the series homogeneous may have been wrong.

That it may be better understood, I give an example to show the difficulties one has to deal with when the figures are inscribed on the map and one tries to draw the curves of equidepartures.

The departures given for Davenport for the years 1891 and 1892 are, respectively, + 37 and + 51. Those of Dubuque, Chicago, Springfield and Des Moines are, for 1891: + 7, + 10, − 4, − 3; and for 1892: + 16, + 12, + 4, + 4. So the departures of Davenport cannot be taken into consideration.

Even a better example is furnished by the departures + 32, + 20 and + 52 given for Pittsburg for the years 1892, 1893 ane 1894. The maps show us that in reality, instead of the preceding figures, the departures should have been about 0, − 25 and + 5. On the other hand, the map obtained for 1899 by using the figures in Bigelow's tables differs obviously, in many details, from that one made with the figures of the *Monthly Weather Review.*

I am aware that the figures cannot be quite exact, the causes of error being many and various; still, it is worth while to note the fact that the departures are only approximate in order not to draw too many conclusions from a study of the maps.

The study of the geographical distribution of the departures suggests that at each point the phenomenon of the variation of annual pressure is governed by the passage of waves having different centers of origin. To study in a really scientific manner the direction and the velocity of the displacement of these waves, as well as the phenomenon of interferences which must occur, the maps that I have been able to draw are insufficient. But, nevertheless, they are suggestive; moreover, all the particularities can be studied, and all the deductions to which a comparison of the maps lead, may be verified, by using a method of research which I shall outline further on.

There is another point which, notwithstanding its evidence, should especially be noted. The real signification of the fact that an annual mean of the atmospheric pressure is slightly too high or too low cannot be defined. An annual mean may be too low owing to an exceptionally low monthly mean. This monthly mean of a certain locality may be abnormal because of a single barometric depression. This depression will only have influenced the means of stations along its path. On the other hand, there is all the complexity of the seasonal changes of pressure which should be discussed.

Therefore, as the maps suggest the existence of waves whose propagation is so slow as to take two or three years to cross the United States, from the Atlantic to the Pacific coast, it would be most interesting to know how far these waves are independent or, on the contrary, affect the seasonal distribution of atmospheric pressure. Before entering into the details of the suggestions to which the study of the maps give rise, I wish to show by a typical example that without any doubt, in certain cases, we have to do with a phenomenon of propagation of atmospheric waves.

The maps of 1891, 1892 and 1893 show the displacement of a maximum whose center, in 1891, was on the Atlantic, N. E. of the New England States; in 1892 it had reached the States of Wisconsin and Minnesota, while in 1893 it had moved on, beyond the Rocky Mountains and Pacific Coast, to the west of San Francisco. This maximum was followed by a very characteristic minimum, whose centre was in the N. E. in 1892, where there had been a maximum the preceding year, and in 1893 the center of most negative departures was over Lake Michigan. As the year of our calendar is quite conventional, one may ask whether the same facts would result from annual means whose year began, for instance, in October, or any other month.

Since it is a question of the displacement of a wave, it is necessary that the crest of this wave, or the hollow which follows it, should pass successively over the localities situated in its path.

In order to make sure that it is allowable to theorize on the tracks followed by the centers of hyperpression shown by the maps, I have taken the trouble to calculate the

consecutive means for the following stations: Eastport, Boston, Buffalo, Detroit, Grand Haven, Green Bay, Duluth and Moorhead. The curves of the following figure graphically express these means.

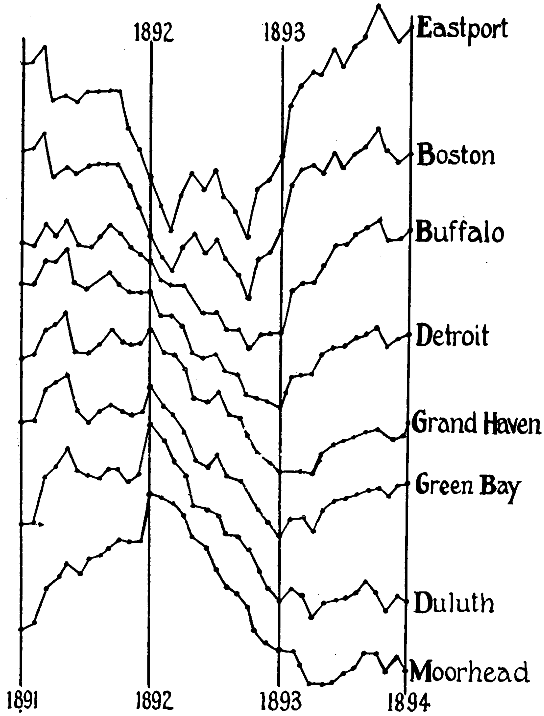

FIG. 4.

Each one of the points of these curves represents the value of an annual mean. The first, of each curve, is given by a mean barometric height for the months January to December, 1891; the second expresses the mean of the months February, 1891, to January, 1892, and so on. It is certain that the curve of Boston is not repeated in all its details.

The wave changes its form as it advances. It is quite plain, however, that the maximum which was observed at Boston as the mean of the months from March, 1891, to February, 1892, and at Detroit as that of the months May, 1891, to April, 1892, does not pass by Moorhead until the months from January to December, 1892. The curves of Buffalo, Detroit and Grand Haven show very plainly the displacement, from E. to W., of the minimum of the variation: October, 1892, to September, 1893; January to December, 1893, and March, 1893, to February, 1894.

It would be easy to give other examples not less characteristic; still, I think that the example given is sufficient to show that my maps do not lead me into error, and that I can confidently go ahead with the examination of several questions of detail. I reproduce below two of the maps I have drawn. They are those of the years 1907 and 1908.

The departures of the *Monthly Weather Review* are given ln hundredths of an inch. Thus, the figure 5 on my map means 0.05 or 0.050. Such an approximation is not sufficient; the departures ought to be given in thousandths of an inch.

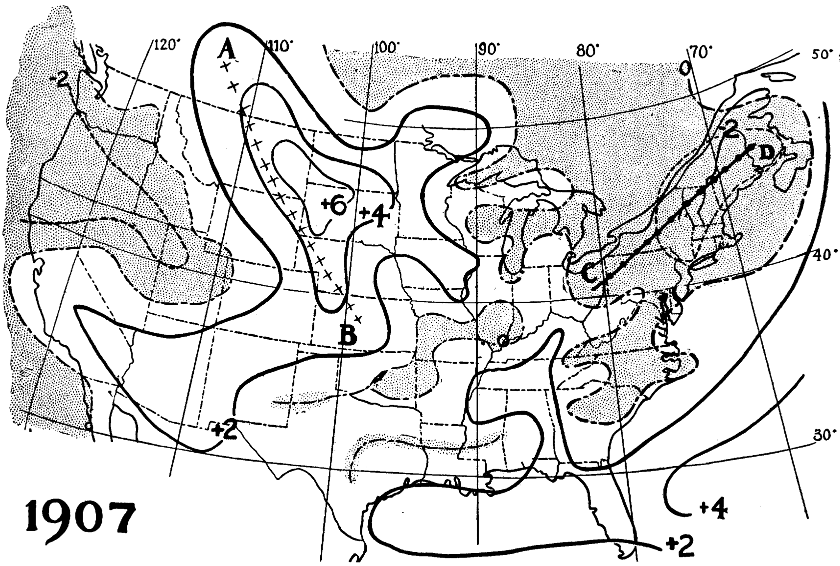

FIG. 5.

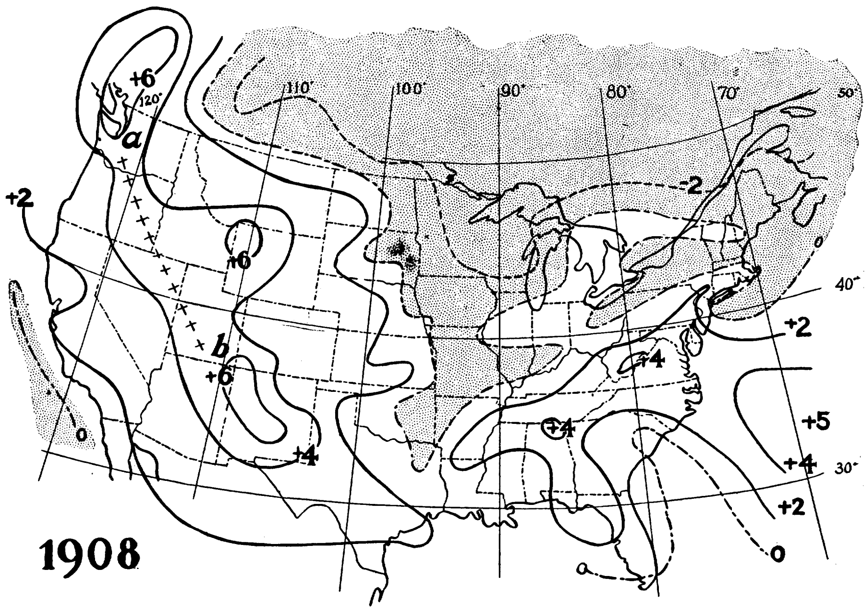

FIG. 6.

When the figures are written on the maps one remarks immediately that the departures of certain localities are doubtful. For example, the figures -4 and 0 given for Red Bluff. It is perfectly possible, however, that the number of departures which are wrong is more considerable than the maps seem to indicate, because certain details of the curves are incorrect.

The wrong departures could easily be found and corrected by using the method of consecutive means. In the same manner it would be possible to verify the accuracy of the details of the curves. When such maps shall be used for forecasting, these corrections and verifications should be made.

The maps for the years 1907 and 1908 are sufficient to show, in an absolutely indisputable manner, that the problem of forecasting the abnormal distribution of atmospheric pressure several months in advance is at present practically approachable.

To make the matter plain, I have drawn some lines which indicate the direction of the waves. The positive wave *AB*, of the map of 1907, seems to have taken the place *ab* in the following year. If this wave maintains itself longer, and if its displacement goes on westward, it will be on the coast, or on the Pacific Ocean, that the axis of highest positive departures shall be found on the map of 1909. A forecast made in this manner would be similar to the weather forecasting made daily by the different weather bureaus. However, a forecast made this way would be arbitrary and as full of uncertainties as forecastings of the weather are.

There is, indeed, another line which the preceding one crosses. It is the negative wave *CD*, on the map of 1907, and while the wave *AB* gives the impression that it moved toward the S. W., the wave *CD*, on the contrary, seems to have moved toward the N. W. or the N. There are, then, to all appearance, two distinct simultaneous movements. But if we imagine two waves, both positive, directed one from the N. W. toward the S. E. and the other from N. E. to S. W., one moving toward the S. W. and the other towards the N. W., the knot formed at the point of intersection will move exactly from E. to W. if the velocity of the displacement of both waves is the same, or following a direction between N. W. and S. W. if the velocity is not the same, or even in one of these directions in the special case that one of the waves is stationary. To well understand how the particularities of the map of 1907 were progressively transformed into those shown on the map of 1908 it would be sufficient to draw the eleven maps of consecutive means, which may be slipped between the maps we already have before us.

The map of 1909 as well, so that the means of each month could be utilized as they come. In this way it would be easy to follow the transformations which take place. Let me say again, that my maps show that the problem of forecasting the anomalies of distribution of pressure is approachable at present. It is this particular problem which is approachable, not the forecasting of the change of climate. From the point of view of this remark it is necessary to understand well what the maps of the departures represent.

They give us indications on the abnormal inflexions of the isobars,—their oscillations. The same departure observed in different places may produce a very different effect. A given departure, let us say negative, may signify a greater abundance of cold winds, or rainy winds, in a certain locality and precisely the contrary in another place.

Then, on the other hand, it is necessary to know the season of the year during which the maximum of the deviation occurs. This last point, however, necessitates a series of investigations before it can be taken into consideration. For the time being I am forced to restrict the field of my researches. I can only examine the annual means, because I am obliged, in the first place, to pass in review generalities

concerning the tendencies of variation. It is only in this way that it will be possible to get at the results without becoming bewildered.

If we look now at the special questions which present themselves we must begin by saying a few words on the velocity of propagation of barometric waves. The maps show that sometimes the anomalies of atmospheric pressure succeed each other rapidly during several years, while other groups of years are characterized by similar situations or by a very slow movement of the areas of positive or negative departures. A study of the diagrams published in the report of Sir Norman Locker forces us to admit that in other countries the same phenomenon can be observed, for there are numerous localities where, sometimes, during several consecutive years, the annual means have nearly the same value. From this point of view, the maps which I have drawn from the departures published in the *Monthly Weather Review* can serve as an example.

The positive wave directed from N.W. to S.E., across the plateau region, on the maps of 1907 and 1908, maintained itself from 1903, only undergoing slight oscillations either toward the E. or the W. Moreover, a stationary situation of this kind must be very exceptional.

From their appearance, the maps drawn can be classified as follows:

(a) Indefinite situation (1896, for example); (b) contrast between the N. and the S.,—curves of equal departures directed from E. to W. (1894); (c) a center surrounded by nearly circular curves covering the entire United States (1893); (d) curves directed in such a fashion that the map gives the impression of the existence of intersecting waves. This is most often the case.

Although it is prudent not to draw too many conclusions from the stated facts, yet I wish to mention a few suggestions which follow from the examination of the maps.

In the first place, since this is a phenomenon which, in most cases, acts as if it were a wave movement, it is quite natural to compare the departures observed in the United States with those noted in Iceland, Greenland and on the Atlantic coasts of Europe.*

One wonders if the waves do not originate in the region of Iceland—if the center of the disturbances is not located there. For there is certainly a correlation between the departures noted in Iceland and those of eastern Canada and the Atlantic States. Generally the departures are of opposite character.

To illustrate this fact, I transcribe some annual departures from the general means of the twenty-five years 1876 to 1900:

	BERUFJORD.	MONTREAL.	WASHINGTON.
1876	+ 39	—29	+ 3
77	— 28	0.	+14
78	+ 98	—70	—55
1881	+ 63	—16	— 8
82	— 55	+28	+26
83	—110	+43	+34
84	—118	—13	+ 3
1890	—122	+ 7	0.
91	— 67	+20	+13
93	+ 43	— 9	—18
94	— 39	+13	+ 3
95	+ 91	—12	— 9
98	— 67	+30	— 5

* I have compared the curve of Stykkisholm with that of Ponta Delgada and have formed the curve expressing the differences between the mean pressures observed in these two localities. In most cases the years of exceptional high pressure in Iceland are years of exceptionally low pressure in the Azores. No kind of periodicity is apparent, and it seems that the changes in the pressure observed in the United States do not depend on the differences in question.

I have only chosen typical cases. Other years offer situations quite as interesting. For example, in 1887, 1888 and 1889 the departures observed in Iceland and in the Azores are of an opposite character, and the distribution of the different values of the departures, noted in the United States, is such that it is perfectly legitimate to admit that a considerable part of North America belongs to the waves comprising Iceland and Greenland.

The departures for 1896 and 1897 give us examples of another kind. In both years the predominance of positive departures is such that the compensations must be looked for outside of the regions taken into consideration.

Whatever it may be, the correlation, bearing the character of a seesaw, existing between Iceland and North America, is without any doubt more typical than that between the mean pressures of Cordoba and Bombay, a correlation on which W. F. S. Lockyer strongly insisted.

The initial point of the above statement was the question whether the anomalies observed in the United States take their origin in the region of Iceland, and if it is from there that they spread. It is too soon to affirm it with certainty, because the question necessitates very elaborate discussion. It seems to me that the phenomena of compensation noted are sufficiently remarkable to justify a special investigation of this kind. I intend to enter upon this study later on, when I shall be able to take into consideration the data from all the regions of the globe.

I pass now to the question of periodicity. The question presents enormous difficulties. The maps expressing the distribution of the departures force us to admit that the curves representing the succession of mean values of atmospheric pressure do not permit us to affirm or contradict the existence of certain periods of variations.

If the variations always originated from the same points of the globe, and if from there they would always propagate in the same manner and with uniform speed, the curves of the different localities would represent an immediate repercussion of given oscillations. But such is not the case, and it seems that no curve from any locality can be considered as being individual. Moreover, no departure is independent of the values observed the same year, or observed before at other places.

Therefore, the question of periodicity must be approached in an indirect way. I have examined the variations of the amplitudes of the waves noted on the detailed maps—drawn from Bigelow's figures. At first sight it seems to be the same question as that of the differences between the annual means of Stykkisholm and Ponta Delgada. It is not so, simply because it is not necessarily in Iceland and the Azores that we observe every year the largest departures. To know where the greatest departures occur, and their values, a detailed map is necessary.

The maps drawn for the United States show that the departure — 0.025 observed in St. Vincent, in 1891, is probably correct, and that the figure + 0.023 noted at Portland and Eastport is also correct. The difference of these values is 0.048. It is the maximum amplitude of the waves, inasmuch as there may be a question of annual waves.

The following figures have been obtained in the same way for the years 1891 to 1899:

48, 66, 67, 71, 66, 62, 58, 54, 49.

The amplitudes increase, in consequence, from 1891 to 1894, and decrease from 1894 to 1899. If one considers the curve expressing the frequency of sunspots, the preceding figures become so significant that I think I may affirm that we have again to deal with a new question which should be examined separately.

The amplitudes of the waves give a measure of the principal agent of the dynamical phenomena which regulate the whole system of variations.

I conclude, therefore, by saying that the examination of the annual means of atmospheric pressure observed in the different localities of the United States confirm the principal result of my researches on the variations of the annual means of temperature. That is to say, there exists a dynamical climatology, and the study of the dynamics of climates is perfectly possible.

GEOGRAPHICAL RECORD

AMERICA

MR. JOCHELSON'S FINDS ON ATTU ISLAND. The departure of Mr. Waldemar Jochelson and his wife for the Aleutian Islands, for ethnological studies, was reported in the *Bulletin* (Vol. 40, 1908, p. 753). Some details of his work on Attu Island, the most eastern of our Aleutian possessions, are printed in *Globus* (Vol. 97, 1910, p. 99) from a short report he has sent to St. Petersburg. He has made many excavations and found numerous dwelling places affording much evidence as to the development of material culture among the ancient Aleuts. His collections number 250 specimens, among which are many stone and bone carvings, 13 skulls, a complete skeleton, stone and bone lances and arrow heads, and baskets and other objects woven by women from grass. This grass weaving shows great skill and fine technic. He has also specimens of edible plants and roots, fibers, and 50 phonographic cylinders on which he took folk lore and songs of the Aleuts. He has written his descriptive text, secured a large vocabulary and prepared a grammar of the native speech. He believes that his further work on the Aleutian Islands will have much importance for primitive culture. In the seventh decade of the last century, Dr. Dall made excavations on these islands and Jochelson has been able to verify some of his observations, but he reports that Dall was mistaken in many of his conclusions. The explorer expected to spend last winter on Umnak Island and to carry his collections in April, this year, to Unalaska.

AGRICULTURE AND IRRIGATION IN BRAZIL. It is a sign of industrial health that Brazil has become interested in mixed farming and the possibilities of irrigation. Mixed farming is highly desirable in view of the depression caused by the drop in the coffee market on account of over-production. Attention is called in government reports to the possibilities in rice production, Brazil being one of the great rice consuming countries; and a fair start has been made in this industry on a scientific basis. Wheat production has also been encouraged to a notable extent and the industry is capable of great development. More recently, great activity has been displayed in the irrigation projects of the arid states of Ceara, Parahyba, and Rio Grande del Norte, the government sending a commission to the United States to study our irrigation projects and problems. The provinces in point (*Daily Consular and Trade Reports,* No. 3675, Jan. 3, 1910) have long been known for their severe drought. They lie along the coast